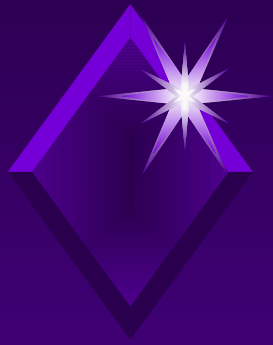


Introduction to Internet Lindsborg, KS

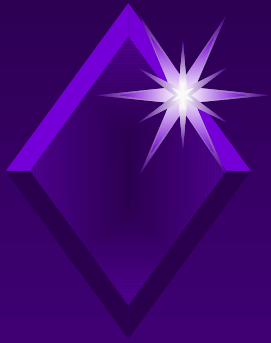
Vint Cerf
WorldCom
January 18, 2002

How does
Internet work?



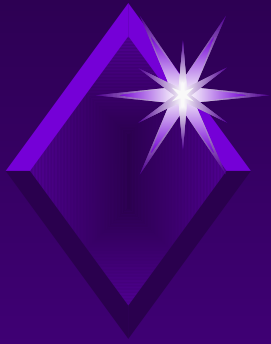
Packet vs Circuit Switching

- ◆ Circuit (telephony) like reserving bicycle lanes from LA to NY!
- ◆ Packet (Internet) like sharing of the highway among high speed cars.



Packet Switching

- ◆ 1961 – Leonard Kleinrock's MIT dissertation thesis
- ◆ 1962 – Paul Baran's "On Distributed Communication" report at RAND
- ◆ 1965 – Donald Davies' "packet" switching node at the UK National Physical Laboratory



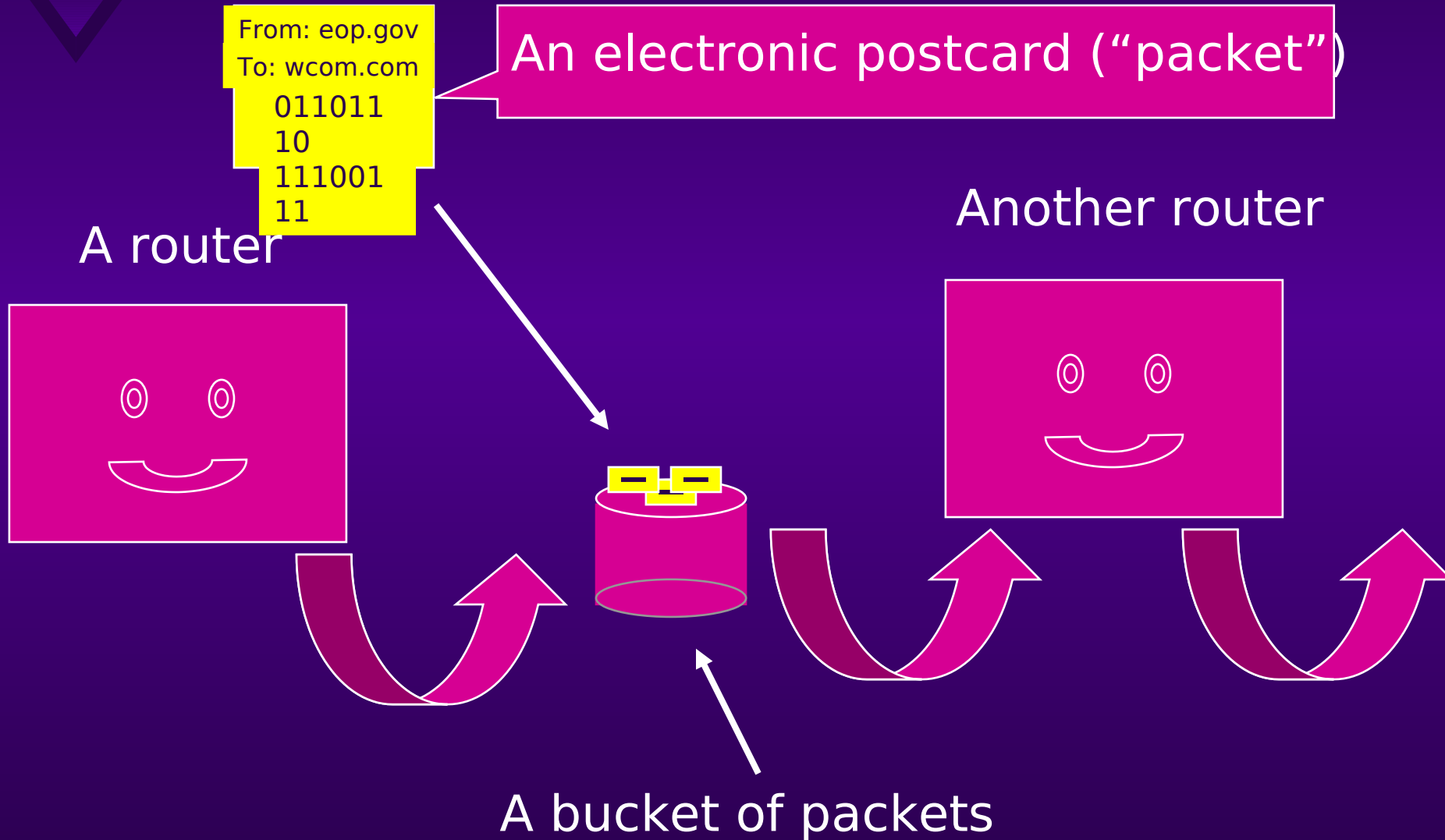
Internet Packet Formats

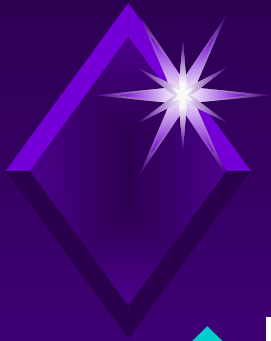
“from” address “to” address Version number CONTENTS

<i>166.45.18.99</i>	<i>204.146.165.100</i>	<i>“4”</i>	<i>“hello”</i>
---------------------	------------------------	------------	----------------

An Internet Packet

The Internet Bucket Brigade



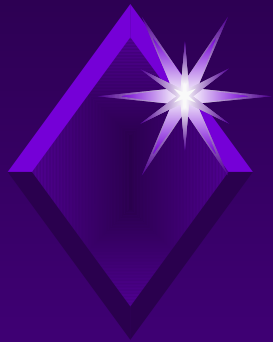


Internet Addressing

- ◆ IPv4 - 32 bits
- ◆ initially, 256 networks ... then mix of:
 - ◆ Class A (128 with 16 M hosts)
 - ◆ Class B (16,384 with 65K hosts)
 - ◆ Class C (2M with 256 hosts)
- ◆ Now, Classless Inter-domain addresses
 - ◆ up to 4.3 Billion hosts, hundreds of thousands of networks

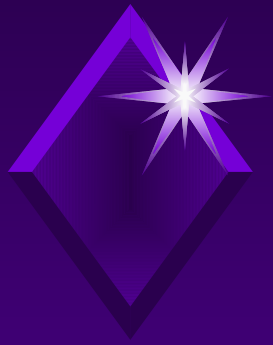
How Does TCP Work?

- ◆ Like Sending a Novel on Postcards
 - ◆ Page numbering (ordering, duplicate detection)
 - ◆ Positive Acknowledgement
 - ◆ Retransmission on Timeout
 - ◆ Finite Mailbox



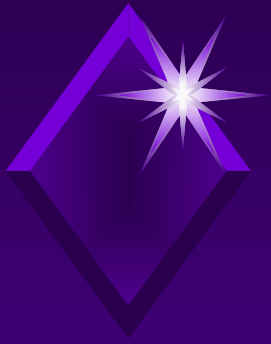
Protocols and Identifiers

- ◆ Protocols are procedures and formats that are used to enable computer to computer communication.
- ◆ To support this, computers share common knowledge of identifiers to make clear which protocols are being used. For example, Internet Protocol version 4 is in use today; IPv6 is coming



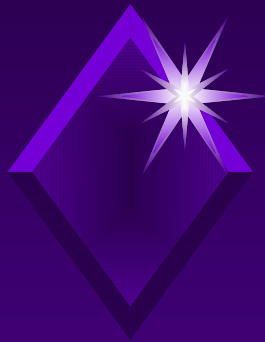
Domain Names

- ◆ .edu, .com, .org, .net, .mil, .gov and .int
- ◆ and country codes: .US, .UK, .FR, .DE...
- ◆ The system is hierarchical and each name is unique: `www.wcom.com`
- ◆ Top level (e.g. .com) managed by a person assigned by the Internet Assigned Numbers Authority



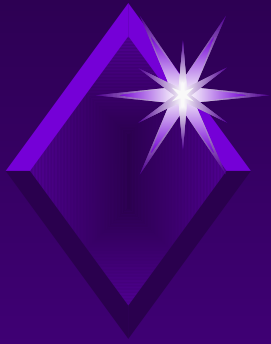
Names and Addresses

- ◆ www.wcom.com is a “domain name”
 - ◆ “com” is the “commercial domain”
- ◆ 208.234.102.119 is an Internet address
 - ◆ this is really just a way to represent a 32 bit number that is how Internet Protocol version 4 represents locations in the Internet, like telephone numbers in the telephone network



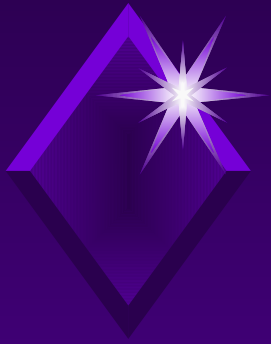
Network Address Translation (NAT)

- ◆ Private Internet Address space (concerns over address space exhaustion)
- ◆ Mapping to/from public IP address space
- ◆ Potentially interferes with end-end operation (e.g encryption)



Routing

- ◆ Gateway-Gateway Protocol (GGP)
- ◆ Autonomous Systems
- ◆ Exterior Gateway Protocols (EGP)
 - ◆ EGP, BGP (v4)
- ◆ Interior Gateway Protocols (IGP)
 - ◆ RIP, SPF, IGRP, OSPF, IS-IS



Firewalls

- ◆ Public Internet is open to everyone
- ◆ Private network interconnection is necessary
- ◆ Access control to limit access to enterprise networks interconnected to the public Internet

Where did it come from?

ARPANET - 1969-1990

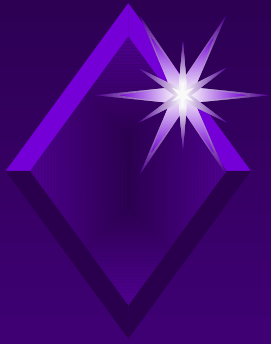
AlohaNet - 1970

Packet Radio, SATNET- 1973

Ethernet (Xerox PARC) 1973

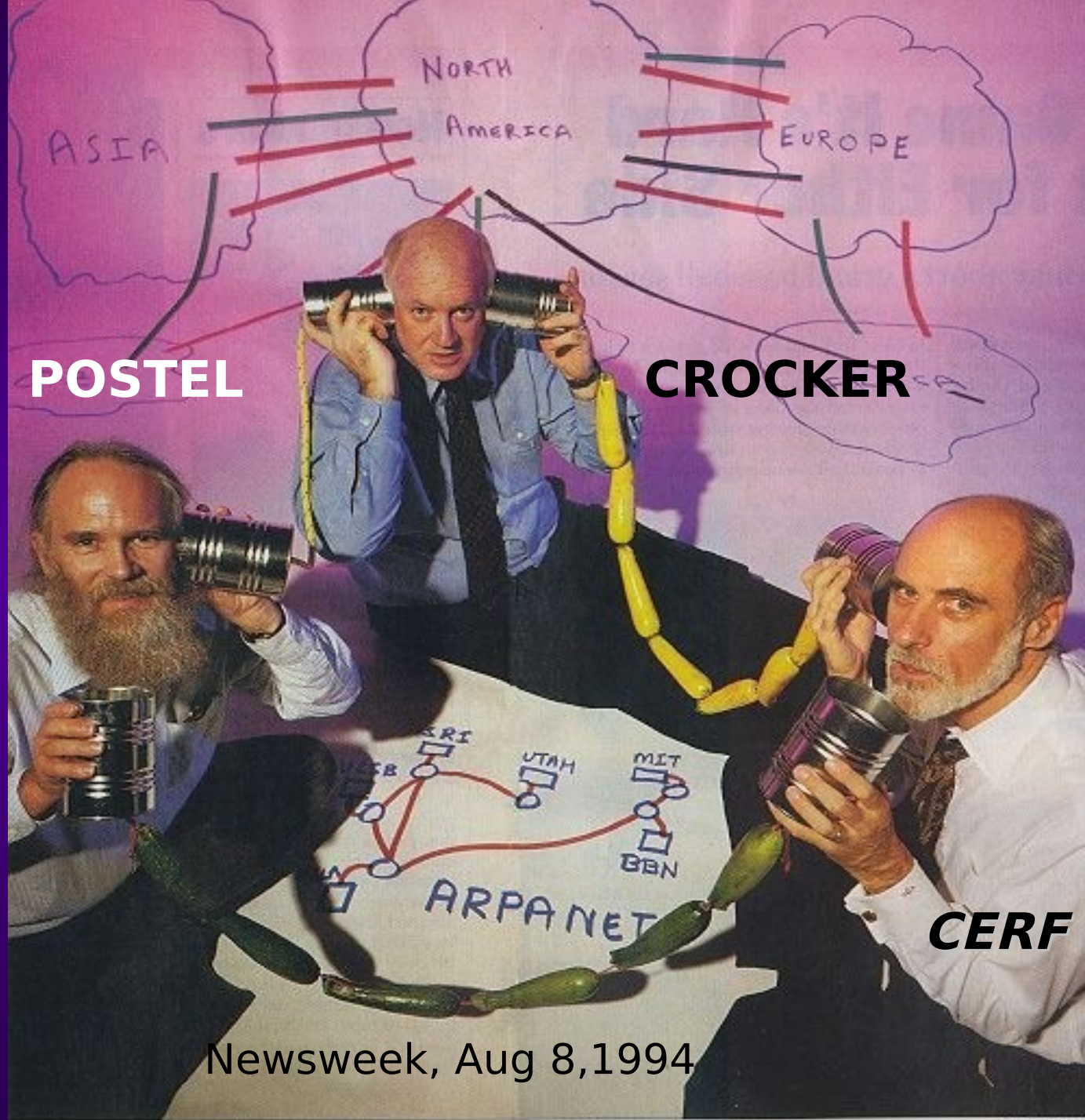
Internet Dev't - 1973-1983

NSFNET - 1986-1995



ARPANET

- ◆ J.C.R. Licklider (MIT, ARPA/IPTO)
- ◆ Robert Taylor (ARPA)
- ◆ Larry Roberts, Barry Wessler (ARPA)
- ◆ Wesley Clark (Washington University)
- ◆ Frank Heart, Bob Kahn, Dave Walden, Willy Crowther, Severo Ornstein et al (BBN)
- ◆ Leonard Kleinrock (UCLA) and Crocker, Postel, Kline, Braden, Cerf et al

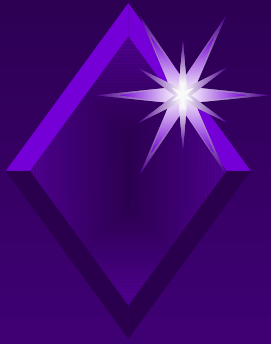


POSTEL

CROCKER

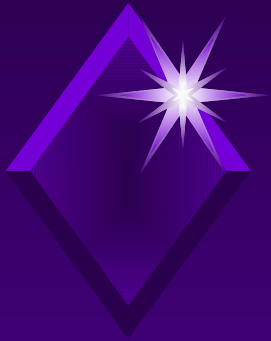
CERF

Newsweek, Aug 8, 1994



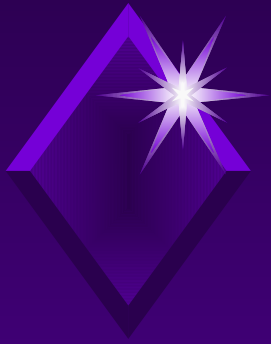
Anecdotes

- ◆ 1973 The back of the envelope
- ◆ 1973 INWG in Univ Sussex (TCP spec)
- ◆ 1974 May IEEE Cerf, Kahn article
- ◆ 1974 The first full TCP spec
(December) – Cerf, Dalal, Sunshine
- ◆ 1975 The three-way handshake – Ray Tomlinson, Bill Plummer, Yogen Dalal



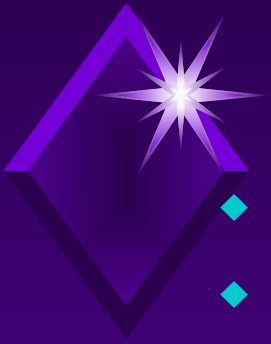
Anecdotes 2

- ◆ 1975 Testing with UCL, BBN – Judy Estrin
- ◆ 1976 The Packet Radio Van [bayshore police]– Don Nielson (SRI Int'l)
- ◆ 1977 The first 3-net Internet test
Ginny Strazisar
- ◆ 1977 Packet Speech on the Net
(Yngvar Lundh, Danny Cohen TCP/IP)



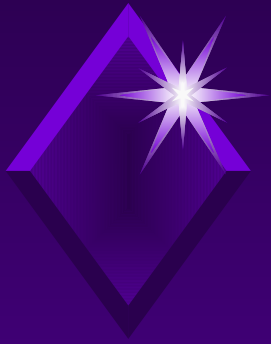
Anecdotes 3

- ◆ 1978 – TCP/IP Checksum – Jon Postel
- ◆ 1979 – ICCB – Dave Clark
- ◆ 1981 – Planning the TCP/IP transition
– Dan Lynch [turning off NCP]
- ◆ 1981 – TCP/IP in UNIX – Bill Joy
- ◆ 1983 – January TCP/IP cutover



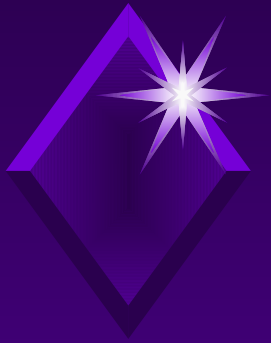
Some Major Milestones

- ◆ 1969 - 1985 Basic Packet Net Research
- ◆ 1974 - Internet design first published
- ◆ 1983 - first major deployment
- ◆ 1986 - first router companies
- ◆ 19XX - FIX East, FIX West
- ◆ 1989 - WWW; MCI Mail/Internet link
- ◆ 1989 - first comm'l services (UUNet, PSINet, CERFNet and CIX)
- ◆ 1990 - ARPANET retired; 1994 - commercial WWW (Netscape)
- ◆ 1995 - NSFNet retired, competitive backbone
- ◆ 1998 - New IANA/ICANN



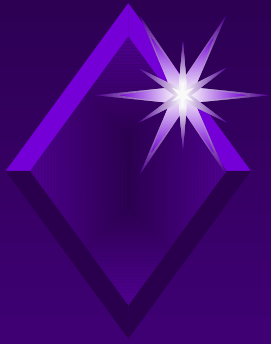
Other milestones

- ◆ Packet speech – experimental, commercial
- ◆ Packet Video – experimental, commercial
- ◆ Airborne Packet Radio – nuclear recovery scenario 1981



More topics

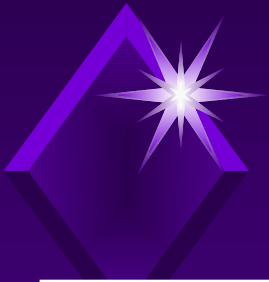
- ◆ Multicasting
- ◆ Anycasting
- ◆ Traffic management (ATM, FR, MPLS)
- ◆ Virtual Private Networking
- ◆ IPSEC
- ◆ Peering
- ◆ Domain name systems
- ◆ Email
 - ◆ (client (POP3, IMAP), server)
 - ◆ relays (SMTP)
 - ◆ MIME
- ◆ World Wide Web
- ◆ ENUM



Some Internet institutions

- ◆ RFCs and NWG
- ◆ ICCB/IAB
- ◆ IETF/IESG
- ◆ IRTF
- ◆ FRICC
- ◆ FNC
- ◆ IANA
- ◆ RIPE-NCC
- ◆ ARIN – America's Registry of Internet Numbers
- ◆ APNIC
- ◆ ISOC
- ◆ ICANN
- ◆ IPv6 Forum

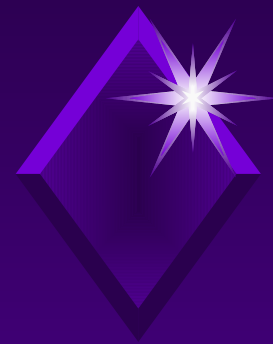
Internet - Global Statistics



22.5 Million Hosts
(Bellcore June 1997)
190? IP countries
(VC est June 1997)
50 Million Users
(Jul 1997)

115 Million Hosts
(NW/TC Jan 2001)
218/246 IP countries
(NW Jan 2000)
513 Million Users
(NUA Aug 2001)

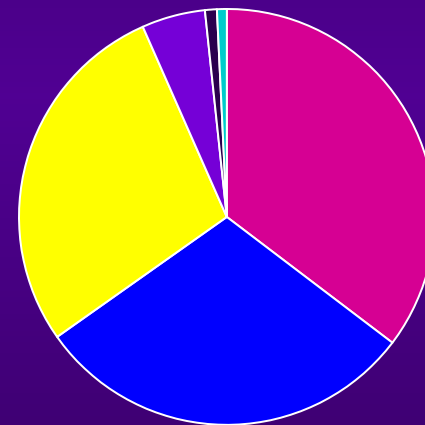
(approx. 1.1 Billion Telephone Terminations)



Users on the Internet – Aug 2001

- ◆ CAN/US - 180.68M
- ◆ Europe - 154.63M
- ◆ Asia/Pac - 143.99M
- ◆ Latin Am - 25.33M
- ◆ Africa - 4.15M
- ◆ Mid-east - 4.65M

- ◆ Total - 513.41 M



■ **CAN/US**

■ **Europe**

■ **Asia/Pac**

■ **Latin Am**

■ **Africa**

■ **Mid East**

(Source www.nua.ie)

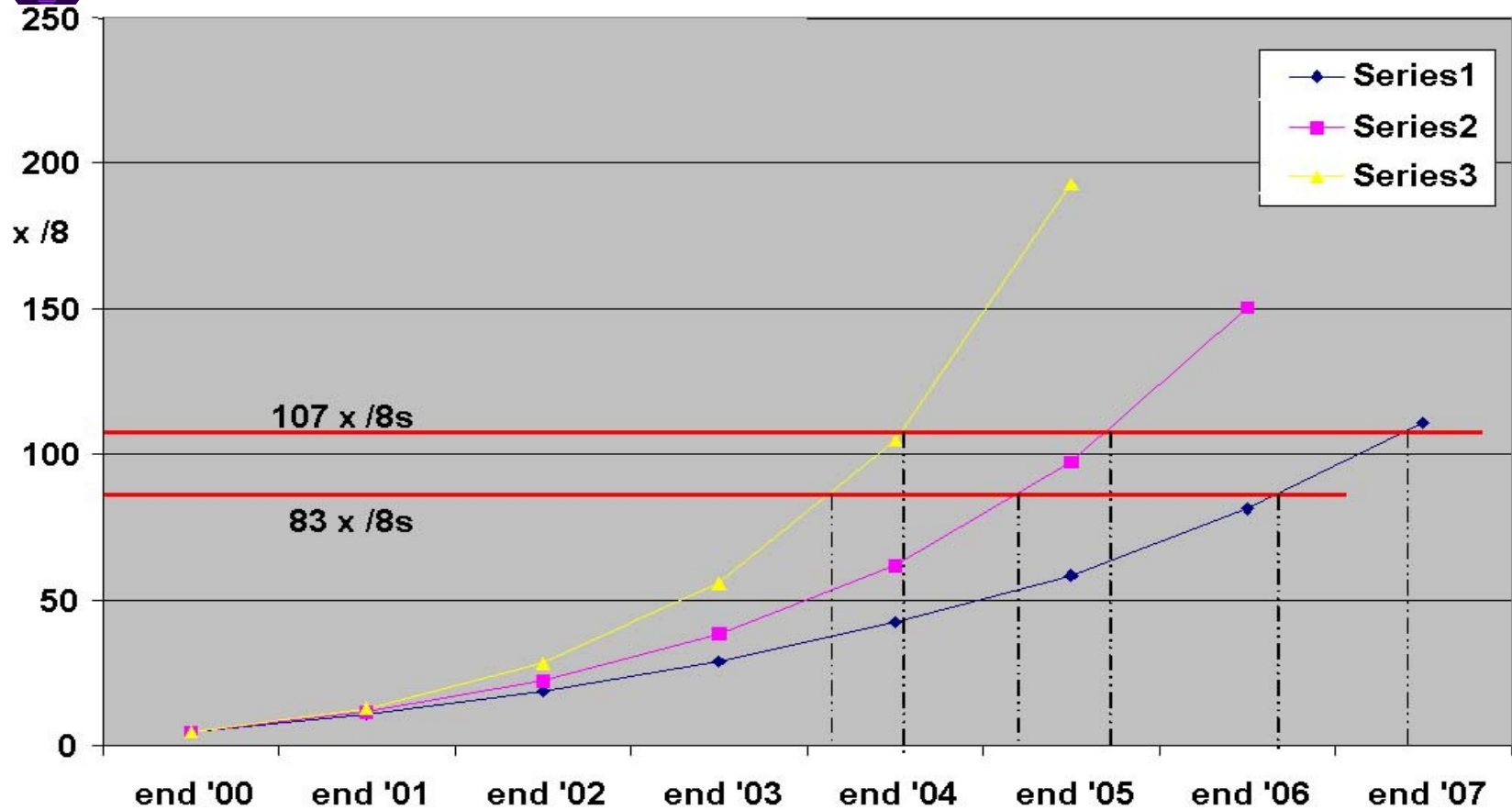
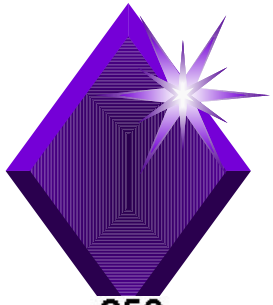


IPv4 Address Consumption

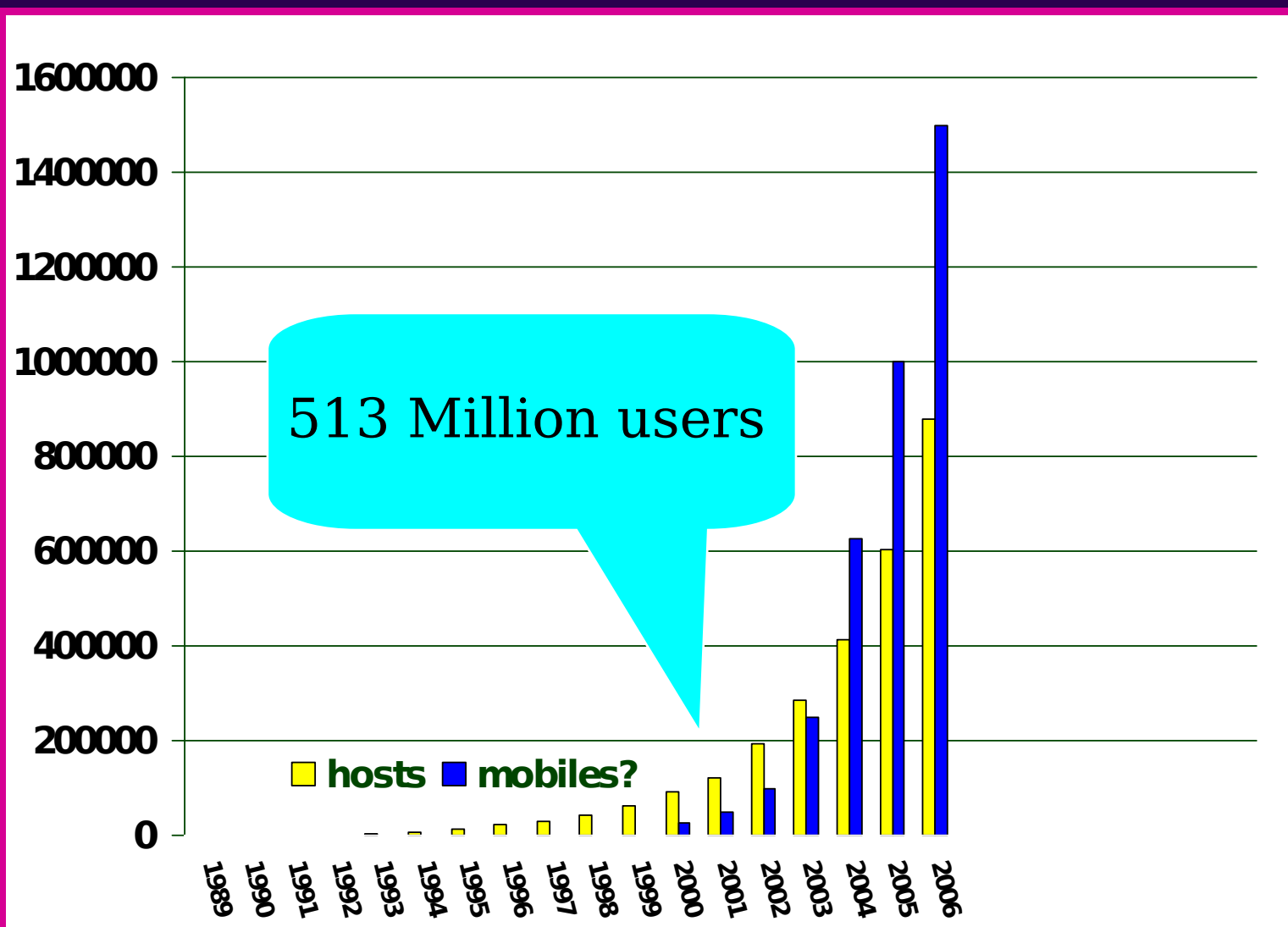
Data from J. Scott Marcus
(then Genuity and now FCC)

May 22, 2001

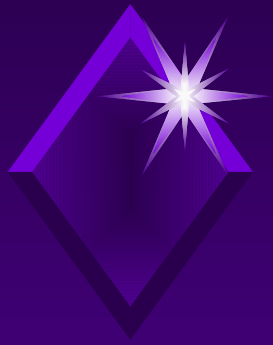
McFadden/Holmes/Mylotte Projection



2006



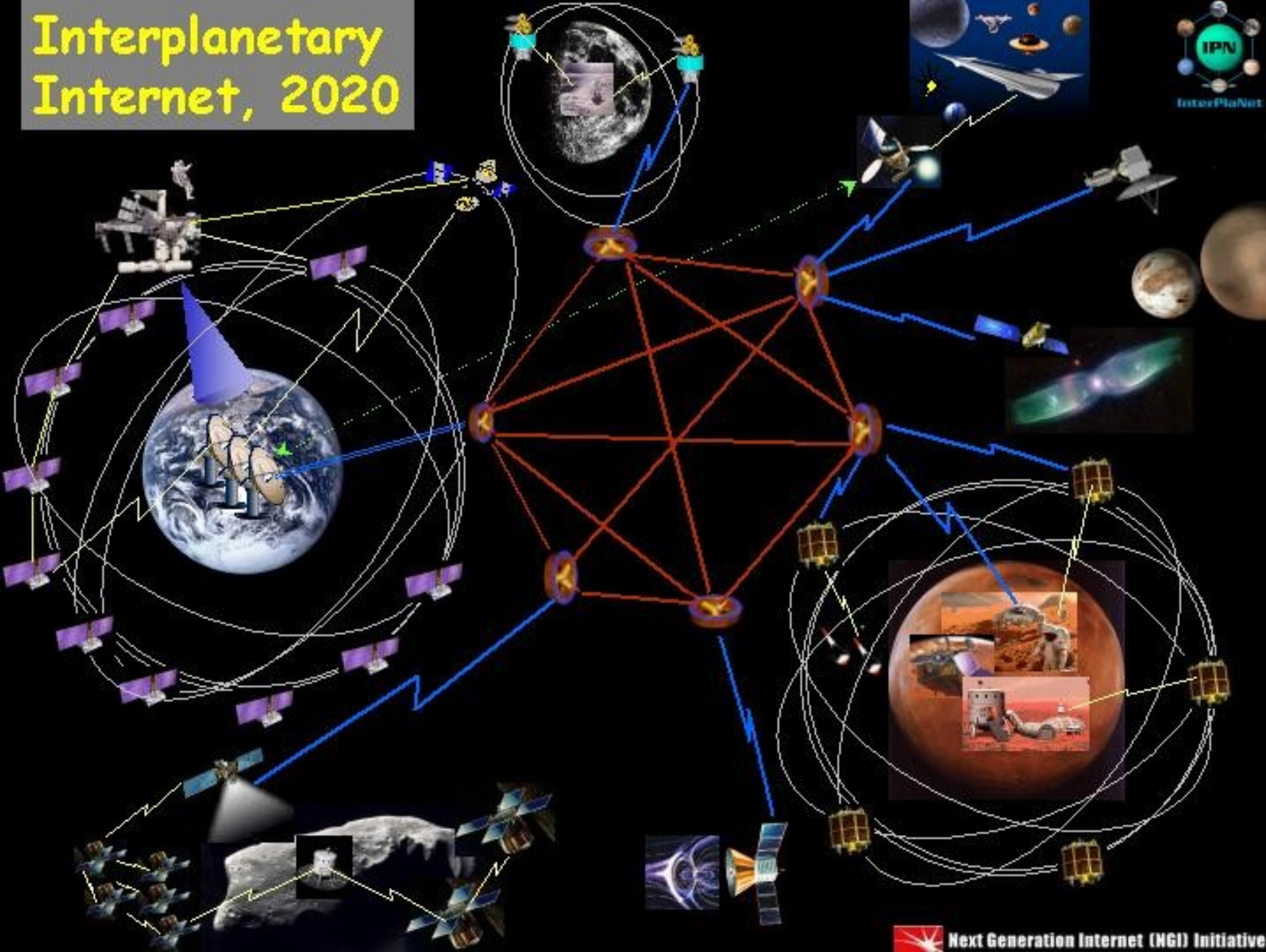
Source: Cerf, based on www.nw.com, Jun 2000 + LM Ericsson

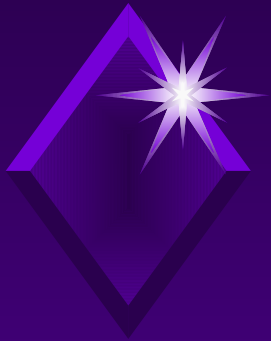


Next Generation Internet

- ◆ IPv6 - 128 bits of addressing
- ◆ Theoretically 10^{38} hosts
- ◆ IPSEC, Flow ID
- ◆ Significant transition effort needed
- ◆ IANA officially announced IPv6 allocations on July 14, 1999

Interplanetary Internet, 2020





Resources

www.wcom.com/cerfsup

www.isoc.org/internet

livinginternet.com

www.gip.org

www.ipnsig.org

www.ipv6forum.com

